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OUTLOOK FOR THE ALASKA HERRING FISHERY IN 1944

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Introduction	P. 1	Summer period	P. 12
Kodiak area	2	Fall period	14
Prince William Sound area.	9	Southeastern Alaska area. . . .	15

INTRODUCTION

In order that optimum use may be made of the herring resources of Alaska, by making the greatest possible withdrawal from the stocks each year while permitting a survival adequate to perpetuate the species, it is necessary to foretell their abundance. The basis on which such a prediction can be made for the Alaska herring was presented in a leaflet published by the Service in 1943[1].

As pointed out in that paper, any change in the abundance level of the stocks of herring - as in any population of living creatures - is governed by the ratio of the birth to the death rate. A prediction of changing abundance, therefore, must be an evaluation of the gain anticipated from the recruitment of young fish into the stock available to the fishery, balanced against the loss to be expected from mortality[2]. Such an evaluation was made for the principal areas for 1943. A review of these predictions compared to the observed conditions in each area, together with an estimate of the probable abundance for Kodiak, for Prince William Sound, and for Southeastern Alaska in the coming year is presented herein.

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[1] Outlook for the Alaska herring fishery in 1943, by E. H. Dahlgren and L. N. Kolloen. Fishery Leaflet 16, March, 1943. Fish and Wildlife Service, Chicago.

[2] Mortality as used herein includes removals from the stock not only by natural causes, but also by the fishery.

Chicago 54, Ill., 1944.

KODIAK AREA

In the Kodiak area the evaluation of probable abundance in 1943 was based on the observation that over a period of years the number of herring in the catch at any age is, within limits, in fixed ratio to the numbers of that same year class which will enter the fishery in the following season. Thus the number of 3-year recruits present in the catches of one year provides a basis for estimating the numbers of that year class which will be available as 4-year fish in the following season. So also, the number of fish present as 4's has a fairly constant relationship to the number of fish of that year class which will enter in their fifth year, which makes possible an estimate of the number of 5-year fish to be expected in the catches of the next season. In fact, the number of fish at any age present in the catch of one year provides a measure of the number of that same year class which may be expected to enter the catches in the following year. Of course this cannot include a measure of the abundance of the fish entering the catch for the first time (3-year fish) so that the numbers at this age to be available in the coming year can be estimated only from the average of the contributions of 3-year fish in the past, and considerable deviations from this average may be expected in any year. However, as these represent only a small part of the total numbers to be taken, this deficiency does not seriously interfere with the prediction.

A complete outline of the procedures involved in establishing the above-mentioned ratios of survival between years is not properly a part of this article. However, it may be stated briefly that they were obtained by comparing the contribution of the offspring of a given spawning in one season (as reflected in its percentage in the catches) with the contribution of that same year class similarly determined for the season following, after weighting each percentage to account for the changes in the abundance of the stocks from year to year. This method provides a measure of the rate at which the members of a given year class augment or decline in available numbers between the two seasons, i.e., with an increase in age. By repeating this procedure so as to include comparisons between all near ages during the life span of a year class in the fishery, and by combining and averaging the ratios between ages for all of the year classes represented in the fishery for the years for which data were available (from 1937 to 1942), the average rate at which increment 3/ occurs during the first years in the life of a brood, and the average rate at which decrement occurs in that brood during its later years in the fishery, became available.

3/ Increment, as used herein, refers to a situation in which the number of recruits entering the adult stock in any year exceeds the number removed by mortality from those already in that stock during the preceding year, which results in a net gain in numbers available to the fishery. Conversely, decrement refers to a situation in which the number of recruits entering is less than the number removed by mortality, so that a net loss in numbers available results.

Because the offspring of any spawning make their contribution over a period of years, it becomes possible, once a year class has entered the fishery, to estimate in advance not only its probable contribution for the following year, but also its probable yield during its entire span in the fishery provided that the intensity of fishing is adjusted so as to permit each brood to survive to a given age.

If the catch could be so regulated as to fulfill the requirement that a portion of each year class survive to a given age, it would result in a stabilized fishery, with the size of the catches governed by the size of the increments. If, under these conditions, the proper age of survival be established, then the optimum yield (i.e., the greatest annual production on a sustained basis) would result. In the Kodiak herring fishery, there is reason to believe that a survival to the 9th year fulfills this requirement. Under these terms nearly 90 percent of the available numbers of each brood are removed during the period of rapid growth (i.e., from the third through the 7th year of life) when the combined increases in individual weight through growth each year compensate for the losses by natural mortality. The survival of 10 percent to the 8th year insures an adult population adequate to make up for the frequent periods of poor survival of spawn.

From the previously mentioned ratios of increment and decrement it was evident that the most probable number of 4-year fish to be available in 1943 would be 3.2 times the number of 3-year fish in 1942, that the number of 5-year fish would be 1.7 times the number of 4-year fish in the former year, that the 6-year fish would be 0.9 times the number of 5-year fish, and that each age group over six years would approximate 50 percent of its numbers in the preceding year. In explanation of these variations between ratios at different ages, it is apparent that only a small part of the total numbers of a year class enter the stock from which the fishery makes its withdrawals in the third year, while the other members of that brood remain separated and unavailable, as they were in their first and second years of life. Furthermore, only a part of the remainder of this brood enter the stocks which are available to the fishermen in their next (fourth) year, so that some remain to enter in their fifth, and a portion of the brood does not become available to the fishermen until their sixth year. The gain by the entry into the stocks of fish previously unavailable between their third and fourth and between their fourth and fifth years exceeds the loss by mortality during those years, so that there is an actual increase in numbers of individuals available to the fishery between the third and the fifth years. The recruitment occurring between the fifth and sixth years nearly, but not quite, compensates for the numbers removed by mortality, so that during this period there is only a slight loss in the numbers available. From this age until the year class is entirely decimated, however, there is no further recruitment, and at the level of fishing intensity which has been imposed, the annual mortality in these older age groups has averaged 50 percent.

It was on the basis of these average rates of increment and decrement at each age, and with a knowledge of the contributions made by each year class in 1942, that the most probable percentual age composition for 1943 was determined. The predicted and the actual percentage composition for the area in the past season are shown in table 1. It will be noted that these values are in close agreement except for the 4- and 5-year fish. The discrepancy between these was due in part to the advance in the opening date of the season from July 1 to June 18, since the younger age groups are more available during this early period than during the mid-season, so that a smaller percentage of five-year fish were taken than was expected. In view of this circumstance, it is apparent that the values established for the average increments at the younger ages and decrements at the older ages approach their true values, and so make possible a fairly accurate prediction of age composition for the coming season.

Table 1.--Comparison of the predicted and actual age compositions For the Kodiak area in 1943.

Age	Year class	Predicted (percent)	Actual (percent)
3rd year	1941	7	11
4th year	1940	24	30
5th year	1939	56	45
6th year	1938	2	3
7th year	1937	1	1
8th year	1936	8	7
9th year	1935	2	2

Since it was evident from the predicted age composition that a large share of the catch in 1943 would be contributed by 4- and 5-year fish, and since these age groups should be available in greater abundance than as 3- and 4-year fish, it was expected that their added contributions would exceed in numbers the decrement in the older age groups. From this it was anticipated that there would be an increase in the abundance of herring in the past season over that of 1942.

As a measure of the change which actually took place, an index of abundance was established for 1943 to compare with former years. This was accomplished by comparing the average catch per vessel per day of fishing in the past season to the mean size of catch made by the average vessel during comparable periods of time in former years. This index, which is in terms of numbers of barrels, was weighted by the average number of fish taken per barrel each year in order to reduce the index to the relative number of individuals taken per unit of effort. By this criterion, the index of abundance did not increase as expected, being 94.2 compared to 102.6 for 1942, but it was considerably above the indices of 1941 and 1940, which were 65.5 and 81.1 respectively.

A part of the decline in 1943 may be attributed to unfavorable fishing weather during August, which led to a considerably reduced availability during this period, so that the true abundance may have been somewhat higher than estimated. Aside from this, however, it is apparent that the abundance of the dominant 1939 year class was overestimated, and that the failure to show an actual increase must be attributed in part, at least, to the fact that this year class, on which the success of fishing so largely depended, was not as abundant as was anticipated.

The average ratios of increment and decrement established for the years 1937 - 1942, on which the prediction of age composition and abundance for the past season was based, have been revised by including the 1943 data. This revision shows that, on the average, there have been 2.9 fish in the catch in their 4th year for each one present in its third; 1.6 individuals in their 5th year in the catch for each one present in its fourth; 0.8 the number present in their sixth year for each in its fifth; and that the established ratio of 0.5 individuals past age six surviving for each one which was present in the catch of the previous season has remained unchanged.

Within the limits of accuracy of the established ratios of increment and decrement at each age, which limits are governed by the accuracy with which the data reflect: (1) the true percentage age composition of the stock and (2) the true changes in abundance level, it is possible to estimate not only the probable abundance and the age composition for the coming year, but also what yield in the coming season will result in a survival approximating that of the past years of the fishery. The estimates of each of these will be given in the following paragraphs.

As to prediction of abundance in the coming season, an estimate of future yield must have as its basis the actual catches of previous years. It has been frequently demonstrated that the abundance of herring in the Kodiak area, as well as in the other areas, has been greatly influenced by the presence in the stock of the offspring of one or more of the especially successful spawnings. As a measure of the degree to which the dominance of certain year classes has influenced the yield of past seasons, and so the extent to which it may be expected to influence future yields (including that of 1944), the catches of all years for which data are available (1936 - 1943) were converted to numbers of fish taken from each year class on the basis of: (1) percentage contributions at each age, (2) average weight at each age, and (3) total tonnage taken; and the contributions of each of the several year classes were totaled. These estimates of the number of fish taken from each year class are shown in table 2.

These data forcefully demonstrate that great differences have existed in the amount contributed by the various year classes, and are a reflection of the great variations in the success of spawning which occur from season to season. In appraising the totals credited to the several year classes, it must be understood that only the 1934 brood has made its full contribution. The year classes preceding this are not represented in their early

Table 2.--Estimated numbers of herring taken from each year class in the Kodiak district (quota area only) from 1936 to 1943 (in millions of fish).

Year of hatch	Year of capture								Total removed from each year class
	1936	1937	1938	1939	1940	1941	1942	1943	
1936	2.5	2.1	0.8	0.8	0.6				6.8
1927	6.9	5.5	3.6	1.3	.3				17.6
1928	5.8	4.6	4.2	2.1	.3				17.0
1929	6.5	4.9	3.5	2.6	.7				18.2
1930	10.8	8.1	4.6	2.8	.7	0.3			27.3
1931	137.1	104.1	67.8	43.8	10.0	3.9	0.2		366.9
1932	2.9	4.4	11.3	4.9	1.7	3.6	.4	0.1	29.3
1933	2.4	6.0	5.6	4.3	2.3	1.8	.5		22.9
1934	.8	4.0	7.1	6.4	4.4	4.0	.5	.1	27.3
1935		2.9	11.4	38.0	27.6	28.9	5.7	3.4	117.9
1936		1.8	24.0	130.6	64.6	106.7	28.5	10.6	366.8
1937				2.1	2.5	7.9	2.7	1.8	17.0
1938					.5	5.8	4.2	5.8	16.3
1939						27.4	62.1	81.1	170.6
1940						.8	14.9	72.4	88.1
1941								25.5	25.5
Total removed each year	175.7	148.4	143.9	239.7	116.2	191.1	119.7	200.8	1,335.5

years, and those following have not yet completed their contributions. Nevertheless, it becomes quite evident that great differences exist in the ability of the various year classes to contribute and that, of the several classes now in the fishery, 1936 was a highly successful one (but has been largely exhausted), that those of 1937 and 1938 were poor and will contribute little, and that those of 1939, 1940, and 1941 were considerably above average. With the year classes of 1940 and 1941 being in the age groups of ascending abundance so that they may be expected to contribute greater numbers in 1944 than in 1943, and with the 1939 year class still expected to be a heavy contributor, a rise in abundance in the coming season over that of the last is almost sure to follow.

If there is to be an increase in the numbers of herring available in the coming season, an increase in the catch should follow. The problem of determining the catch which will utilize this increase to best advantage can be solved within the limits of accuracy of the established increment and decrement ratios. This follows because these averages provide not only a means of predicting the age composition in the coming year, but also of estimating the total contribution in numbers of fish to be expected from any year class from its contributions to date, together with an estimate of the rate at which each of these year classes will contribute its numbers each year during its span in the fishery. From these ratios the numbers of fish to be removed from each year class in 1944 which will fulfill the requirement of survival to the 9th year can be estimated, and from this estimate the number of barrels to be taken can be calculated.

The basis on which the potential yield of a typical year class can be estimated from the numbers which it has contributed in its first years in the fishery, together with the rates at which that brood will contribute its numbers during its span in the fishery are shown in table 3. These estimates were obtained from the established averages of increment and decrement and are, in reality, an expression of those ratios on a percentage basis.

Table 3.--Average rates at which a year class will contribute its numbers to the fishery, based on the average rate of increment and decrement.

Age	Percentage contributed at each age	Cumulated percentage contributed at each age
3-year fish	6.3	6.3
4-year fish	18.1	24.4
5-year fish	29.0	53.4
6-year fish	23.3	76.7
7-year fish	11.6	88.3
8-year fish	5.8	94.1
9-year fish	3.0	97.1
10-year fish and older	2.9	100.0

From this table it follows that, under a constant fishing effort of average intensity (which in the past has permitted a survival to the 9th year), the numbers contributed by an average brood as 3-year fish will approximate 6.3 percent of the potential contribution of that brood; the numbers contributed by that brood in the third and fourth years combined will approximate 24.4 percent of its total; the numbers contributed in the third, fourth, and fifth years combined will approximate 53.4 percent of its total, etc., until, by the time the brood reaches its tenth year, no further significant contribution can be expected. Thus, with the total contribution of a year class at any age known, its potential contribution during its span in the fishery can be computed. This assertion will hold only if the fishing effort is constant from year to year.

The estimates of numbers of fish caught in the Kodiak fishery each year (table 2) take no account of the differences in amount of fishing effort expended in making the catches in the various years. Because the amount of effort expended has varied widely from year to year, these figures, while they do show the relative abundance of the year classes within each year, are not a true reflection of the relative abundance of any of the year classes between years. In order to correct for this difference in fishing effort in estimating the potential production of each year class, the numbers of individuals taken from each class in each season has been weighted by the abundance index of that year. From this revision an estimate of the numbers of fish of each year class which would have been removed each season if the fishing effort had remained constant, is available. From these weighted estimates, the potential contribution of each of the year classes during their life, and the numbers of fish to be contributed by each in 1944 was calculated. These estimates are shown in table 4. From these estimates the most probable distribution of ages for 1944 is also available. If the incoming 1942 year class is of average abundance so that it will represent 8 percent of the total, then the most probable percentage age composition for the coming season is as shown.

The yield in barrels of the number of fish shown in table 4 can be calculated, since the numbers and average weight at each age are known. The combined total of all year classes is slightly more than 300,000 barrels. With a catch of this magnitude in the Kodiak district, the year classes now in the fishery should survive in some numbers through their ninth year. If this follows with the withdrawal of the number of fish allotted, then the abundance will be maintained at a level sufficiently high to insure an adequate spawning population. Future heavy contributions by year classes not yet in the fishery may permit of further increases in the catch, but even if the next year classes (those of 1942 and 1943) are of low numerical strength, there will be a sufficient reserve of older fish to avert a sudden decline. The influx of large numbers of recruits from the three consecutive spawnings of 1939, 1940, and 1941 has bolstered the stocks to a level considerably above that of recent years. The increased harvest reflects this fortunate occurrence.

Table 4.--Estimates of the numbers of herring to be contributed by each year class during its life, the numbers to be contributed in 1944, and the percentage occurrence of each age group in the catches in that year, based on average rates of increment and decrement. In millions of fish.

Age	Year class	Potential total contribution	Contribution expected in 1944	Percentage contribution
3rd year	1942		21.2	8 1/
4th year	1941	327.0	59.2	22
5th year	1940	327.5	95.0	36
6th year	1939	321.2	74.8	28
7th year	1938	20.1	2.3	1
8th year	1937	16.9	1.0	...
9th year	1936	344.0	10.3	4
10th year	1935	116.4	1.7	1

1/ The contribution of the 3-year fish is an average of the contributions made by the several year classes which have entered the fishery in the past 8 years.

PRINCE WILLIAM SOUND AREA

The prediction made for the 1943 season in the Prince William Sound area covered two separate periods of the fishery, summer and fall. The occurrence of separate "runs" of herring, which is peculiar to this area, is discussed in the 1943 report. For those not acquainted with the characteristics of these summer and fall runs their outstanding features are here reviewed.

The summer run is available in greatest abundance from the opening of the season in late June, until mid-July. The fall run, when present, usually begins in late August and reaches its peak in September. A distinct period of slack fishing marks the interval between the two.

Age composition data since 1937 have established that the summer run is composed largely of individuals of the younger age groups, i.e., of 3- to 5-year and infrequently of 6-year fish. The fall run, on the other hand, when of some magnitude, has been composed largely of individuals six years of age and older. The existence of the two runs is attributed to a differential schooling of the herring, with the young fish being available in greatest numbers in the summer, and the older individuals being most available in the fall.

Table 5.--Estimated numbers of herring taken from each year class in the Prince William Sound District from 1937 to 1943 (in millions of fish)

Year of hatch	Year of capture														Total contribution of each year class
	1937		1938		1939		1940		1941		1942		1943		
	Summer	Fall	Summer	Fall	Summer	Fall	Summer	Fall	Summer	Fall	Summer	Fall	Summer	Fall	
1926	...	2.4	...	1.2	...	1.1	...	...	...	...	...	...	...	...	4.7
1927	0.8	10.8	...	2.6	...	1.9	...	...	...	...	...	...	...	...	16.1
1928	...	9.4	...	4.9	0.3	.3	...	...	...	...	...	...	...	...	14.9
1929	2.3	8.2	0.2	10.6	.3	1.9	...	...	...	...	...	...	...	...	23.5
1930	1.5	8.5	.6	7.9	.5	2.9	0.2	0.4	...	0.1	...	...	...	...	22.6
1931	13.0	88.9	2.9	85.8	1.8	40.1	1.1	4.0	0.2	.2	...	...	...	...	238.0
1932	6.1	5.2	1.5	11.0	1.0	3.0	...	.3	.2	.3	...	...	...	...	28.6
1933	8.4	10.3	2.3	8.8	1.2	2.3	.2	.4	...	.3	...	...	...	...	34.2
1934	23.7	8.7	10.9	5.1	1.2	.4	.4	.4	.2	.6	...	...	...	...	51.6
1935	95.6	21.3	140.2	47.5	87.0	42.4	24.0	32.3	10.3	18.5	0.1	0.5	...	...	519.7
1936	1.5	.5	32.9	18.3	138.0	28.6	37.8	44.1	17.9	32.2	...	.7	0.1	...	352.6
1937	...	...	...	...	18.3	1.9	6.8	18.9	6.4	9.5	...	.1	...	...	61.9
1938	...	...	...	...	1.2	.1	9.0	45.9	19.3	14.6	.1	.4	.3	0.1	91.0
1939	...	...	...	...	...	...	...	.7	137.8	8.5	4.5	3.0	11.8	1.5	167.8
1940	...	...	...	...	...	...	...	...	2.3	.4	4.2	1.0	4.0	1.1	13.0
1941	...	...	...	...	...	...	...	...	...	...	.6	...	6.1	6.1	12.8
Total withdrawals by years	327.1		395.2		377.7		226.9		279.8		15.2		31.1		1,653.0

Because of this peculiar individuality of the runs, because the data available on the age composition for the summer and fall periods are not continuous for a sufficient period of years, and because no reliable criterion of relative abundance is available since 1941, it has not been possible to postulate with accuracy the average rates of increment and decrement in this area as was done for Kodiak. Therefore, no prediction of the age composition for the coming year, no estimate of the potential contribution of each of the several year classes, and no precise estimate of the optimum yield for the Prince William Sound fishery can be made. The probable abundance in each period can be based only on a general appraisal of the abundance of the year classes which will contribute to each part of the season.

In Prince William Sound as in the other areas of Alaska the spawnings have met with varied success, some producing in abundance, some being virtual failures. In all years of record, the abundance in this district has been high when dominant year classes, which have resulted from the occasional highly successful spawnings, have been present in the catches. In those years in which such dominant classes were young, and so present in the summer fishery, the catches in that period were high; in those years in which these dominant groups were older and had entered the fall fishery, the catches in that period were high until, with increasing age, mortality finally decimated the brood.

Table 5 shows the estimated contributions (in millions of fish) made to the summer and fall fisheries by each year class during the fishing seasons of 1937 through 1943. During this period four dominant year classes have appeared in the fishery, those of 1931, 1935, 1936, and 1939. In the summer fishery, the contributions of the 1935, 1936, and 1939 year classes accounted for the successful operations of 1937 through 1941. The 1931 year class had already entered the fall fishery by 1937, so that no evidence of its earlier dominance in the summer fishery is available. The 1935 year class yielded a total of some 223 million individuals as 3-, 4-, and 5-year fish in the summers of 1938, 1939, and 1940. The 1939 year class contributed some 138 million 3-year fish in 1941, the last year of large-scale summer operations, and 16 million more in the following two years of restricted fishing. When the contributions of these dominant year classes are contrasted to the contributions of the less successful broods, their importance in the fishery becomes clearly evident.

As to the fall fishery, the 1931 year class, which yielded 219 million fish to the fall fisheries from 1937 to 1940, after having already contributed to the summer fisheries from 1933 to 1935 and to the fall fishery of 1936, was exhausted by 1940. Because of the heavy contributions in early life by the 1935 and 1936 year classes, their numbers had become so reduced by the time of their entrance into the fall fishery (at age 6) that they were unable to make heavy contributions to that fishery. With no further contributions available from the 1931 year class, with the 1935 and 1936 year classes unable to continue their heavy support, and with the remaining year classes of 1932, 1933, 1934, and 1937 of minor importance, the fall operations of the years following 1940 have been of meagre success.

It is evident, then, that the abundance of herring in Prince William Sound has been, and will continue to be, dependent on the presence of dominant year classes, and that the relative success of the summer and fall periods of fishing will reflect the age of those year classes which are present. With this background knowledge the predictions made for the season of 1943, and the outlook for 1944 can be better evaluated.

Summer Period

The prediction for the summer run in 1943 was that three year classes would support the fishery, that of 1939 as 5-year fish, that of 1940 as 4-year fish, and that of 1941 as 3-year fish. Because the first two of these (1939 and 1940) would not be adequate to support an intensive fishery, and should not have extensive withdrawals imposed against them, it was urged that operations in the district be curtailed. This conclusion was based on the fact that the extensive withdrawal already made against the 1939 year class (146 million fish) in 1941 was an excessive removal for one year, and in compensation its contribution as 4- and 5-year fish had to be reduced in order that it might survive in sufficient numbers to enter the fall fishery. In addition to this, the poor showing made by the 1940 year class during the 1942 season indicated that it was not of exceptional abundance. The value of the 1941 year class was unknown, but it was considered ill-advised to impose an intensive drain on this year class, with its members being only 3-year fish.

Because of the limited quota allotted, none of the plants in this district were operated during the summer period. Some 25,000 barrels were taken by units of the Kodiak fleet, which made trips to Prince William Sound prior to the closing of the district on July 15. These fish were transported to Kodiak for processing, so that age composition data were obtained. These data are shown in table 6.

Table 6.--Percentage age composition of the 1943 summer fishery in Prince William Sound

Age	Year class	Percentage composition
3rd year	1941	27
4th year	1940	18
5th year	1939	53
6th year	1938	1
7th year	1937	...
8th year	1936	1

As expected, the chief support of the fishery was from the year classes of 1939, 1940, and 1941. The dominance of the 1939 year class is again demonstrated by its 53 percent contribution to the catch. As the contribution of the entering 1941 year class was 27 percent, it must be assumed that this year class, too, is of considerable numerical strength.

Lacking the operation in this district of a definite number of boats making a consistent search for fish, no exact measure of abundance, based on the catch per vessel per unit of fishing time, can be made. The only available measure is one based on reports and observation. That the abundance was high is supported by the fact that the Kodiak boats were able to obtain capacity loads with the expenditure of little effort. Further confirming evidence was the report by both herring and salmon fishermen that schools of herring were present in nearly all of the bays in the western entrance of the sound.

This increase in abundance was not unexpected because, in the Sound as at Kodiak, there is evidence of an ascending recruitment from the third to the fourth year and from the fourth to the fifth year, so that an increase in available numbers of the 1939 and 1940 year classes occurred between the 1942 and 1943 seasons. Then, also, the entry of the 1941 year class in considerable abundance added to the total stock. These factors combined to increase the abundance in the district considerably above that of the previous year.

In the coming year the summer fishery in this district will be supported by the year classes of 1940, 1941, and 1942 as 5-, 4-, and 3-year fish, respectively, with the possibility that at least a part of the 1939 year class will remain available during the summer period as 6-year fish. As has been demonstrated, the 1939, 1940, and 1941 year classes are far above average abundance in the Kodiak area. Since successful year classes have been demonstrated to occur in all districts if they occur in one, it is anticipated that these same year classes will be of sufficient abundance to contribute heavily in Prince William Sound. With at least two year classes of above average abundance in the fishery, neither of which has yet contributed in large numbers, there is reason to believe that the abundance in this area will be high during the summer period of 1944.

Notwithstanding the favorable prospects for a high abundance of herring in the summer run, good management requires that only a moderate withdrawal be made during this period. This follows because it is this same body of fish, if allowed to mature past the fifth year, which will support the future fall fisheries. Unless the removals from the summer fishery are adjusted so as to permit the survival of considerable numbers of the successful year classes to their sixth year and beyond, not only will the formerly important fall fishery remain a minor one, but there will be no reserve of adults with which to sustain the fishery over a period of light recruitment. Such periods have been common in the past and it may be assumed that they will recur in the future.

Fall Period

A review of the fall operation for the past season establishes that the run during this period was a failure, as predicted. The fall run, dependent as it is for its success on the abundance of the older age groups, held little promise of a good yield. The dominant 1935 and 1936 year classes had already been decimated by the heavy withdrawals made against them in the summer operations of 1937 to 1941 and in the fall operations of 1939 and 1940, so that their numbers were not sufficient to support heavy fishing after that year. The following two year classes of 1937 and 1938 were of minor importance, and could not be expected to contribute heavily. In confirmation of this, the age composition data for the fall fishery (table 7) show that only two percent of the catch was made on fish past their sixth year. Only the younger age classes, which are not available in abundance during the fall, were taken. The catch of 8,000 barrels made by the two vessels which operated in the district was not unexpectedly small.

Table 7.--Percentage age composition of the 1943 fall fishery in Prince William Sound

Age	Year class	Percentage composition
2nd year	1942	1
3rd year	1941	68
4th year	1940	12
5th year	1939	17
6th year	1938	1
7th year	1937	...
8th year	1936	1

In the coming year the 1939 year class, which has been established as being considerably above average abundance, should enter the fall fishery in large numbers. Because past records indicate that occasionally a year class in its sixth year has distributed its contribution between the summer and fall periods, rather than appearing wholly in the fall, it is possible that this year class may contribute an unexpectedly large share of its numbers to the summer fishery at the expense of the fall run. If this should occur, then, the summer run will be of higher, and the fall run of lower, abundance, than expected. It is certain that the success of the fall fishery will depend largely on the availability of this year class, now that the 1935 and 1936 classes are known to be exhausted, and the 1937 and 1938 classes to be of minor importance. If the availability follows the established pattern, the prospects for a successful fall operation in 1944 and in the years immediately following are good.

In summary, it is apparent that because of the entrance of several successful year classes into the summer fishery, coincident with the maturing of the 1939 year class into the fall fishery, the prospects for 1944 are favorable. The year classes now in the summer fishery should furnish an abundance of fish, but since the support for the fall fishery in future years rests on the survival of these groups through age five, the catch during the summer period must remain at a relatively low level. With the support of the abundant 1939 year class good catches can be anticipated in the fall fishery. The decline of recent years has been checked, and a new cycle of abundance begun. If carefully guarded, the resource should continue to yield well over a long period.

SOUTHEASTERN ALASKA AREA

It has been demonstrated repeatedly that the degree of success attending the spawning each season follows the same general pattern in all of the areas. The series of three spawning failures which followed the highly successful batch of 1931 resulted in a decline which was more apparent in the Southeastern than in either the Prince William Sound or Kodiak areas, although the latter two were also affected by coincident failures. This difference followed because the Southeastern fishery had been intensively exploited for a longer period than had either of the others, so that the reserve of older fish required to maintain the fishery over such an extended period of low recruitment was smaller than that of the other areas, and insufficient to permit continued heavy withdrawals. Because no reserve of older fish existed, and because withdrawals exceeded the replacements during this period, the abundance in this area began to decline after 1934, and had reached a very low level by 1938.

The above statement is made with particular reference to the Cape Ommaney fishery, from which an average of more than 80 percent of the Southeastern catch was made during the decade preceding its decline in 1938. Since the catch of the Southeastern area is so largely dependent on the supply of herring available at the Cape, the factors which have governed the ability of this district to produce have controlled the success of the entire operation.

The great differences in the contributions of the various year classes, which have been so largely responsible for the changing abundance in this district, are shown in table 8. This estimate of the numbers of fish which were taken from each year class in the Cape Ommaney district during the decade 1929 - 1938 is based on the same procedure as was applied to the Kodiak data shown in table 2. The magnitude of the dominant 1926 and 1931 year classes and the relative insignificance of the 1930, 1932, 1933, and 1934 classes is clearly evident.

Table 8.--Estimated numbers of herring taken from each year class in the Cape Ommaney district of Southeastern from 1929 to 1938 (in millions of fish)

Year of hatch	Year of capture										Total removed from each year class
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	
1919	0.4										0.4
1920	.9	0.4									1.3
1921	.4	.4									.8
1922	4.4	1.0	0.5								5.9
1923	5.3	2.4	1.5								9.2
1924	9.8	4.7	.5								15.0
1925	20.5	7.0	6.5	9.7							43.7
1926	396.5	257.6	129.1	70.2	112.8	5.5					971.7
1927	6.7	60.2	56.6	28.8	52.7	20.2		0.1			225.3
1928		1.3	25.7	27.9	45.3	16.8	1.3	.2			118.5
1929			31.5	90.3	98.0	36.2	1.8	1.4	0.2	0.1	259.5
1930				9.7	34.0	18.5	7.9	2.7	1.8	.1	74.7
1931					11.3	323.8	232.2	80.5	55.1	4.6	707.5
1932						.4	9.7	10.4	11.9	1.6	34.0
1933							3.1	17.4	17.5	1.8	39.8
1934								10.8	47.2	2.9	60.9
1935								.5	118.5	38.1	157.1
1936									5.4	13.0	18.4
Total removed each year	444.9	335.0	251.9	236.6	354.1	421.4	256.0	124.0	257.6	62.2	2,743.7

Following the decline, by 1937, in the available numbers of the 1931 year class, only the offspring of the 1935 spawning remained in any numbers to support the fishery. Because these were not of sufficient abundance to maintain the level of fishing intensity imposed, the abundance dropped and it was deemed necessary to close the waters immediately adjacent to Cape Ommaney to fishing in 1939 so as to offer added protection to this population. In the year following, when it became evident that the 1936 year class was not of adequate abundance to support the fishery, operations in the entire area were suspended. Because the 1937 and 1938 spawnings were unsuccessful, the two limited operations carried on after this closure (in 1940 and 1941) were failures. No operation was attempted in 1942.

The prediction of an increased abundance in this district of Southeastern in 1943 was based on the knowledge that each area has been influenced by the same spawning successes and failures. From this it was assumed that the 1939 year class, which first appeared in numbers as 3-year fish in Prince William Sound in 1941, and which so largely supported the operation in the following year at Kodiak, would be present in Southeastern in numbers sufficient so that the abundance in the Cape Ommaney area would have at least partially recovered from the low level at which it stood from 1938 through 1941.

That the abundance was reestablished at a level above that of recent years is evident from a comparison of the average size of the catches made in this district during the past season to that made by comparable vessels in preceding years. The catches on which this index was based were weighted so as to account for the differences in numbers of fish taken per barrel each year, in a manner similar to that described for Kodiak. The index so established is shown in table 9. The index of 128 for the past season when compared with those of the previous years is evidence that a marked increase has occurred in the numbers of fish available in this district.

Table 9.--Index of relative abundance of herring in the Cape Ommaney district of Southeastern from 1931 to date, based on the average numbers of fish made per delivery.

Year	Index	Year	Index
1931	93	1936	61
1932	132	1937	79
1933	92	1938	38
1934	87	....	..
1935	68	1943	128

That this abrupt rise in abundance has resulted from an influx of new recruits into the stock, and is not the result of older age groups again becoming available, is evident from an examination of the age composition data for the district, shown in table 10. As expected, none of the older age groups made significant contributions.

Table 10.--Percentage age composition of the Cape Ommaney district of Southeastern in 1943.

Age	Year class	Percentage composition
3rd year	1941	13
4th year	1940	59
5th year	1939	21
6th year	1938	4
7th year	1937	2
8th year	1936	1

The proportion of 5-year fish of the 1939 year class to the 4-year fish of 1940 was somewhat less than anticipated. However, in view of the apparent high abundance of the stock, this does not necessarily imply that the 1939 spawning was less successful than anticipated, but may be interpreted as indicating that the 1940 spawning produced an even greater number of offspring than did that of 1939.

It was the heavy contributions of the 1939 and 1940 year classes which were so largely responsible for the increase in abundance of herring in this Cape area in the past season. These year classes alone should be adequate to support a fishery of some magnitude in 1944. In addition to these broods, however, the 1941 year class may be expected to add considerable numbers to the stock available next year. This follows because the above-average contributions in the past season of this year class as 3-year fish in Kodiak and in Prince William Sound as well as in this area gives promise that a third consecutive spawning has met with success.

With the 1940 and 1941 year classes being in the age groups of ascending abundance so that an increase in their numbers may be expected, and with the continued support of the 1939 year class, from which only a small withdrawal has so far been made, there should be an abundance of herring at Cape Ommaney in 1944. This augmented abundance should permit of an increased harvest, and if the year classes which make this increase possible prove to be as abundant as the data at hand indicate, then the operations in this area may soon again be expanded to approach their former importance. When this is achieved, withdrawals need be limited only to an amount proportionate to the capacity of the stock to make replacements.

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